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Growing and physical properties of indium-doped zinc selenide crystals

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Electrophysical, optical, and luminescence properties of zinc selenide crystals doped with indium have been studied. The presence of electrically active donor In^{+}_{Zn} centers responsible for the extrinsic absorption and electrical conductance of the crystals has been established. The conductance compensation in ZnSe:In crystals has been shown to be due to cationic vacancies. The In^{+}_{Zn} donors and the cationic vacancies form associative defects responsible for the long-wavelength ZnSe:In luminescence. The high crystal conductivity (about 5 $\Omega^{-1}\cdot cm^{-1}$) is attained by the ZnSe:In annealing in melted zinc resulting in extraction of the cationic vacancies.

Исследованы электрофизические, оптические и люминесцентные свойства монокристаллов селенида цинка, легированных индием. Установлено наличие электрически активных донорных центров In^{+}_{Zn}, ответственных за примесное поглощение и электропроводность кристаллов. Показано, что компенсация проводимости в кристаллах ZnSe:In осуществляется вакансиями катионов. Доноры In^{+}_{Zn} и вакансии катионов образуют ассоциативные дефекты, ответственные за длинноволновую люминесценцию ZnSe:In. Высокая проводимость кристаллов (около 5 $Ом^{-1}\cdot см^{-1}$) достигается в результате отжига ZnSe:In в расплаве цинка, приводящего к экстракции катионных вакансий.

Zinc selenide crystals are of promise for development of light emitting diodes in blue spectral region. To ensure the light emitting structures, the basic ZnSe crystals should exhibit the minimum possible dislocation concentration. In this connection, the single crystals obtained by free growing are attractive. The method has been described in detail in [1–4]. To provide a high level of current carrier injection, a high electric conductance of the crystals is to be attained. To that end, a procedure has been developed [4] for ZnSe doping with indium in the course of the growing. The indium concentration in the crystals was varied from 10^{16} to 10^{19} cm^{-3}. The impurity content in ZnSe:In was determined by mass spectrometry.

This work is done to elucidate the nature of centers defining the physical properties of ZnSe:In crystals. Furthermore, undoped ZnSe crystal as well as ZnSe:In samples annealed in zinc melt have been studied.

Electrophysical characteristics of the studied crystals are presented in the Table below. The resistivity was calculated using the van-der-Pau method. The electron concentration and mobility were determined from Hall emf measured within the temperature range of 77 to 400 K. It is seen from the Table that the resistivity of ZnSe:In crystals is rather high even at In concentrations of 10^{19} cm^{-3}. A trend to the crystal resistance is observable as the In content increases from 10^{17} to 10^{19} cm^{-3}. It is to note for comparison sake that the resistivity of undoped crystals is about 10^{10} $\Omega\cdot cm$ and the electron mobility is 500 $cm^2/V\cdot s$. Thus, the electron mobility is